CROSS TRACK INFRARED SOUNDER (CrIS)

Sensor Requirements Document (SRD)

for

NATIONAL POLAR-ORBITING OPERATIONAL ENVIRONMENTAL SATELLITE SYSTEM (NPOESS) SPACECRAFT AND SENSORS

Prepared by

Associate Directorate for Acquisition
NPOESS Integrated Program Office

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The following paragraphs of the CrIS SRD can be found in the SRD "Common Section". The following SRD Common Section Table of Contents is for reference only. Page numbers have been intentionally omitted.

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1 SCOPE

1.1 IDENTIFICATION

This Sensor Requirements Document sets forth the requirements of the Cross-track Infrared Sounder (CrIS) which is part of the National Polar-orbiting Operational Environmental Satellite System (NPOESS) series of polar-orbiting spacecraft. The CrIS instrument forms a key component of the larger Cross-track Infrared/Microwave Sounding Suite (CrIMSS) and is intended to operate within the context of the CrIMSS architecture.

1.2 SENSOR OVERVIEW

The CrIS provides cross-track measurements of scene radiance to permit the calculation of the vertical distribution of temperature and moisture in the Earth's atmosphere. It also provides supporting measurements for a variety of other geophysical parameters as listed in the Integrated Operational Requirements Document (IORD) (Paragraph 3.2.1.1). The CrIS shall consist of a Michelson interferometer infrared sounder covering the spectral range of approximately 3.5 to 16 microns. It will be operated together with a co-registered microwave cross-track sounder suite of instrument(s). Note: The current notional baseline performance level assumed for this microwave suite specification will be no less than that currently projected for the Advanced Microwave Sounder Unit-A (AMSU-A) and the Advanced Microwave Sounder Unit-B/Microwave Humidity Sounder (AMSU-B/MHS) microwave sounders, as scheduled to fly on the National Oceanic and Atmospheric Administration (NOAA) K-N' series spacecraft.

One CrIS flight unit is intended to be provided to meet an early flight opportunity on the NOAA N' satellite to be available for launch in 2004. The NOAA N' microwave sounding sensor channels will be provided by the AMSU-A and MHS instruments. Three additional CrIS flight units are needed for the NPOESS C1, C3, and C5 spacecraft which will be available for launch in 2007, 2009, and 2010. The microwave sensors to be used with the CrIS as part of the larger CrIMSS sounding suite are TBS. The purpose of a possible early flight opportunity on NOAA N' is to meet user requirements in advance of the first NPOESS launch and to provide early improved IR sounder capability. These data are processed and delivered to the users in the form of Raw Data Records (RDRs), Sensor Data Records (SDRs), and Environmental Data Records (EDRs).

1.3 DOCUMENT OVERVIEW

This document contains all performance requirements for the sensor suite. This document also defines all sensor-spacecraft interfaces for the sensor suite. The contractor should use the document as the basis of a proposed sensor suite specification. The documentation listed in section 2.0 follows an approach of minimum specs and standards. The contractor may add to or revise the documents listed in section 2.0 in coordination with the government. The term “(TBD)” applied to a missing requirement means that the contractor should determine the missing requirement in coordination with the government. The term “(TBS)” means that the government will supply the missing information in the course of the contract. The term “(TBR)” means that the requirement is subject to review for appropriateness by the contractor or the government. The government may change "(TBR)" requirements in the course of the contract.

Appendix A contains a definition of the terms used throughout the document. Appendix B, NPOESS survivability requirements, is classified and will be made available after contract award. Appendix C is a Sensor Data Record Characteristics section presently (TBR). Appendix D of the TRD contains the NPOESS EDR requirements. Appendix E contains the RDRs and EDRs required for each Central and Field Terminal (TBR). Appendix F defines the acronyms and abbreviations used throughout the document. Appendix G describes Potential Pre-planned Product Improvements. Appendix H is the Verification Cross Reference Matrix (TBD).

1.3.1 CONFLICTS

SRDX1.3.1-1
In the event of conflict between the referenced documents and the contents of this specification, the contents of this specification shall be the superseding requirements.

SRDX1.3.1-2
In the event of a conflict involving the external interface requirements, or in the event of any other unresolved conflict, the contracting officer shall determine the order of precedence.

1.3.2 REQUIREMENT WEIGHTING FACTORS

The requirements stated in this specification are not of equal importance or weight. The following three paragraphs define the weighting factors incorporated in this specification.

a. ***Shall*** designates the most important weighting level; that is, mandatory. Any deviations from these contractually imposed mandatory requirements require the approval of the contracting officer.
b. **S*hould*** designates requirements requested by the government and are not mandatory. Unless required by other contract provisions, noncompliance with the *should* requirements does not require approval of the contracting officer.
d. ***Will*** designates the lowest weighting level. These *will* requirements designate the intent of the government and are often stated as examples of acceptable designs, items, and practices. Unless required by other contract provisions, noncompliance with the *will* requirements does not require approval of the contracting officer and does not require documented technical substantiation.

1.4 SYSTEM CLASSIFICATIONS N/A

2 APPLICABLE DOCUMENTS

2.1 GOVERNMENT DOCUMENTS

The following documents of the exact issue shown form a part of this SRD to the extent specified herein. In the event of conflict between the documents referenced herein and the contents of this specification, see Section 1.3.1. Tailoring of documents in this section is (TBR).

SPECIFICATIONS:

Military

DOD-E-83578A May 96	General Specification for Explosive Ordnance for Space Vehicles
Mil-A-83577B Feb 88	Moving Mechanical Assemblies for Space Launch Vehicles
MIL-C-24308 Apr 97	General Specification for Connectors, Electric, Rectangular, Non-Environmental, Miniature, Polarized Shell, Rack, and Panel
MIL-C-38999 Dec 97	Connectors, Receptacle, Electrical, Circular, Breakaway Wall Mounting Flange, Removable Crimp Contacts, Sockets, Series III, Shell Size 25, Metric

STANDARDS:

Federal

FED-STD-209E Sep 92	Airborne Particulate Cleanliness Classes in Cleanrooms and Clean Zones

Military

MIL-STD-461D Jan 93	Electromagnetic Emission and Susceptibility Requirements for the Control of Electromagnetic Interference
MIL-STD-462D Jan 93	Measurement of Electromagnetic Interference Characteristics
MIL-STD-975 Aug 94	NASA Standard Electrical, Electronic, and Electro-mechanical (EEE) Parts List, Revision M, 5 May 1998
MIL-STD-1540C Sep 94	Test Requirements for Launch, Upper Stage, and Space Vehicles
MIL-STD-1541A Dec 87	Electromagnetic Compatibility Requirements for Space Systems

MIL-STD-1553B Jan 96	Digital Time Division Command/Response Multiplex Data Bus

Department of Commerce/NOAA None (TBR)

OTHER PUBLICATIONS:

Regulations

AFM 91-201 7 Oct 94	Explosive Safety Standards
EWR 127-1 31 Mar 95	Eastern and Western Range Safety Requirements

Handbooks None (TBR)

Bulletins None (TBR)

Other

GPS ICD 200, REV C 19 January 1995	"NAVSTAR GPS Space Segment/Navigation User Interface"(U)
GPS ICD 203, REV B 22 Dec 1993	"NAVSTAR GPS SA/AS Requirements" (U) SECRET

(Contractors requiring copies of specifications, standards, handbooks, drawings, and publications in connection with specified acquisition functions should obtain them from the contracting activity or as directed by the contracting officer.)

2.2 NONGOVERNMENT DOCUMENTS

The following documents of the exact issue shown form a part of this SRD to the Extent specified herein. In the event of conflict between the documents referenced herein and the contents of this specification, see Section 1.3.1.

SPECIFICATIONS: None (TBR)

STANDARDS:

CCSDS 203.0-B-1 Jan 87	CCSDS Recommendations for Space Data System Standards. Telecommand, Part 3: Data Management Service, Architectural Definition, Issue 1
CCSDS 701.0-B-2 Dec 87	CCSDS Recommendations for Advanced Orbiting Systems, Networks and Data Links, Architectural Specification

ISO/TC 209 (ISO/DIS 14644-1) Jan 97	Cleanrooms and Associated Controlled Environments
National Aerospace Standard (NAS) 411 Rev 2, 29 Apr 94	Hazardous Materials Management Program
SAE AS1773 May 88	Fiber Optics Mechanization of an Aircraft Internal Time Division Command/Response Multiplex Data Bus

DRAWINGS: None (TBR)

OTHER PUBLICATIONS: None (TBR)

2.3 REFERENCE DOCUMENTS

The following documents are for reference only and do not form a part of this specification. They are listed here because various parts of the SRD refer to them.

SPECIFICATIONS:

Military None (TBR)

STANDARDS:

ANSI/ISO 9899- 1990	Programming Language—C
DOD 5200.28-STD Mar 88	Department of Defense Trusted Computer System Evaluation Criteria
EIA/IEEE J-STD- 016 30 Sep 95	Standard for Information Technology, Software Life Cycle Processes, Software Development, Acquirer-Supplier Agreement
MIL-STD-129M 1 Jun 93	Marking for Shipment and Storage Notice 1, 15 Sep 89
MIL-STD 961D Aug 95	DoD Standard Practice for Defense Specifications, w/ Notice 1
MIL-STD-882c Jan 93	System Safety Program Requirements

MIL-STD-1246C Apr 94	Military Standard Product Cleanliness Levels and Contamination Control Program
MIL-STD-1522A May 84	Standard General Requirements for Safe Design and Operation of Pressurized Missile and Space Systems, Notice 2: 20 Nov 86; Notice 3: 4 Sep 92
MIL-STD-1542B Nov 91	Electromagnetic Compatibility (EMC) and Grounding Requirements for Space Systems Facilities
MIL-STD-1543B Oct 88	Reliability Program Requirements for Space and Launch Vehicles
MIL-STD-1547A Dec 92	Parts and Materials Program for Space and Launch Vehicles
MIL-STD-1809 Feb 91	(USAF) Space Environments for USAF Space Vehicles
MIL-STD-1815A	ADA Programming Language
TM-86-01	Technical Manual Contract Requirements

Department of Commerce

DOC Sep 95 Edition Sep 95	National Telecommunications and Information Administration, Manual of Regulations for Federal Radio Frequency Management

NOAA

S24.801 Nov 72	Preparation of Operations and Maintenance Manuals, Revised Apr 97
S24.806 Jan 86	Software Development, Maintenance, and User Documentation, Revised Apr 94
S24.809 Dec 89	Grounding Standards

NASA

PPL-21 March 1995	Preferred Parts List, Goddard Space Flight Center (Updated May 1996)
SP-R-0 022A (JSC) 9 Sep 74	General Specification, Vacuum Stability Requirements of Polymeric Material for Spacecraft Application

NASA Tech Memo 100471	Orbital Debris Environments for Spacecraft Designed to Operate in Low Earth Orbit
SP 8031 1969	NASA Space Vehicle Design Criteria/Structures

OTHER PUBLICATIONS:

Regulations None (TBR)

Handbooks

DOD-HDBK-263B (date)	Electrostatic Discharge Control Handbook for Protection of Electrical and Electronic Parts, Assemblies, Equipment
MIL-HDBK-340 1 Jul 85	Application Guidelines for MIL-STD-1540B
DOD-W-83575 Jun 96	Gen Spec for Wiring Harness, Space Vehicle, Design and Testing
MIL-I-46058	Insulating Compound, Electrical (for Coating Printed Circuit Assemblies)
1985	Handbook of Geophysics and Space Environments
AFM 15-111 1 Sep 96	Surface Weather Observations

Bulletins None

Other

TRD for NPOESS (current version)	Technical Requirements Document (TRD) for National Polar- Orbiting Operational Environmental Satellite System (NPOESS) Spacecraft Payloads
IRD for NPOESS (current version)	Interface Requirements Document (IRD) for National Polar-Orbiting Operational Environmental Satellite System (NPOESS) Spacecraft
IORD for NPOESS 28 Mar 96	Integrated Operational Requirements Document (IORD) for National Polar Orbiting Operational Environmental Satellite System (NPOESS) Spacecraft Payloads

ASTME-595-93 (current version)	Standard Test method for Total Mass Loss and Collected Volatile Condensable Materials for Outgassing in a Vacuum Environment
Attachment C S-480-80 Revised December 1994	AMSU-A Instrument Performance and Operation Specification (for the EOS/METSAT Integrated Programs); NASA GSFC
SYS/AMS/J0105/ BAE 03 Feb 1993	AMSU-B Instrument System Specification (British Aerospace)

(Technical society and technical association specifications and standards are generally available from reference libraries. They are also available in technical groups and using federal agencies. Contact the contracting officer regarding any referenced document not readily available from other sources.)

3 SENSOR REQUIREMENTS

3.1 DEFINITION

3.1.1 SENSOR DESCRIPTION

SRDK3.1.1-1
The CrIS shall be a passive infrared Michelson interferometer that measures the radiation data that is to be incorporated with other data to satisfy NPOESS EDR requirements (See Appendix D of the TRD).

3.1.2 SENSOR SEGMENTS

The primary system segments and subsystems of the instrument are illustrated in Figure 3.1.2.

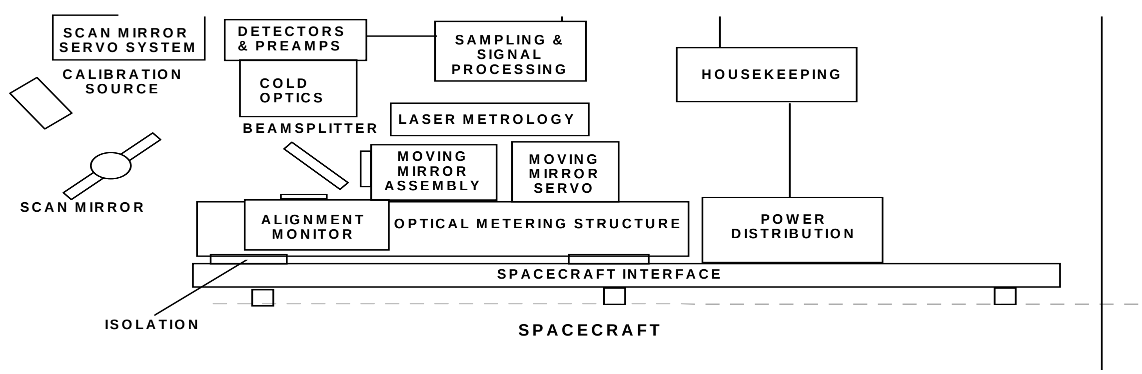

Figure 3.1.2 Notional CrIS Sensor Diagram

3.1.2.1 Satellite Interface Adapter

SRDK3.1.2.1-1
The interface adapter assembly shall allow the instrument to interface to any of the standardized attachment points on the spacecraft.

SRDK3.1.2.1-2
The adapter assembly shall transfer loads, torques, and displacements in the sensor to allow flexible placement of the sensor on the bus.

3.1.2.2 Isolation System

SRDK3.1.2.2-1
Some form of mechanical isolation shall be incorporated into the instrument design if the mechanical force input levels (defined in paragraphs 3.3.12.7.4 and 3.3.12.7.5), from the spacecraft through the attachment points, will degrade instrument performance below limits defined in the contractor's "A" Specification.

3.1.2.3 Optical Bench

A rigid metering structure holding the interferometer subsystem and scan mirror assembly is required to maintain internal sensor pointing knowledge.

SRDK3.1.2.3-1
The optic bench orientation with respect to the satellite bus shall be known to 10% (TBR) of the ground pointing knowledge error.

3.1.2.4 Scan Mirror and Motor

SRDK3.1.2.4-1
The scan mirror shall scan cross-track to the satellite motion, sun-side to space-side. The interferometer and the cross-track microwave instruments should synchronize their start-of-scan at (TBS) intervals.

3.1.2.5 Scan Mirror Servo Subsystem

SRDK3.1.2.5-1
The scan mirror servo subsystem shall control the motion and velocity to the levels required to meet the performance specifications.

3.1.2.6 Interferometer Moving Mirror Assembly

SRDK3.1.2.6-1
The interferometer moving mirror assembly shall employ a proven design approach with demonstrated lifetime and robustness.

3.1.2.7 Moving Mirror Servo Subsystem

SRDK3.1.2.7-1
The moving mirror servo subsystem shall move the mirror in a nearly linear fashion meeting specified velocity error specifications (TBR) during the inteferogram measurement.

3.1.2.8 Beamsplitter

SRDK3.1.2.8-1
The beamsplitter shall be optimized to meet the instrument requirements. An effort should be made to minimize the environmental impact of using hygroscopic materials.

3.1.2.9 Alignment Monitor Subsystem

SRDK3.1.2.9-1
The alignment monitor subsystem shall measure the relative alignment of the two interferometer arm mirrors continuously during interferometer operation.

3.1.2.10 Alignment Subsystem

SRDK3.1.2.10-1
The instrument design shall incorporate a concept for maintaining alignment to the accuracy required to allow EDR threshold values to be met.

3.1.2.11 Aft Optics

Aft reflective optics after the interferometer may be employed to reduce the beam diameter into the cold optics.

3.1.2.12 Cold Optics

SRDK3.1.2.12-1
The aft optics, including a field stop if required, shall be cooled to minimize background radiation on the detector.

3.1.2.13 Detectors & Preamplifiers

SRDK3.1.2.13-1
No less than (TBD) infrared detectors per channel shall be used in the design.

SRDK3.1.2.13-2
Preamplifiers shall be located as close to the detectors as possible to minimize noise pickup.

3.1.2.14 Visible Metrology & Sampling Electronics

SRDK3.1.2.14-1
The sampling electronics shall digitize the interferogram.

3.1.2.15 Calibration Subsystem

Calibration blackbodies and controllers will operate continuously to calibrate the instrument on every cross-track scan as required.

3.1.2.16 Signal Processing

SRDK3.1.2.16-1
The signal processing shall be incorporated (or accomplished) in a manner that assures there is no information loss in the spectral bands. The downlink data stream should include all data required to apply a proper calibration on the ground and housekeeping data required to determine the health and operational state of the instrument as defined in

3.1.2.17. Data compression, either using filtering or decimation of the interferogram or FFTs, is desirable.

3.1.2.17 Housekeeping

SRDK3.1.2.17-1
The housekeeping data stream shall include, at a minimum, all voltages, critical currents, and temperatures of the optic bench and optical subsystems, including the beamsplitter housing, the cold optics, and the detectors.

3.1.2.18 Command & Control

SRDK3.1.2.18-1
The command and control subsystem shall control every aspect of the instrument operation, data taking, and communication with the spacecraft as specified in section 3.2.4.8.

3.1.2.19 Spacecraft Communications

SRDK3.1.2.19-1
Refer to section 3.2.4.8 Data and Command Interface.

3.1.3 SPECIFICATION TREE

As shown in the attached Figure 3.1.3, the requirements for this CrIS SRD flow from the NPOESS Integrated Operational Requirements Document (IORD), the Interface Requirements Document (IRD), and the NPOESS Technical Requirements Document (TRD).

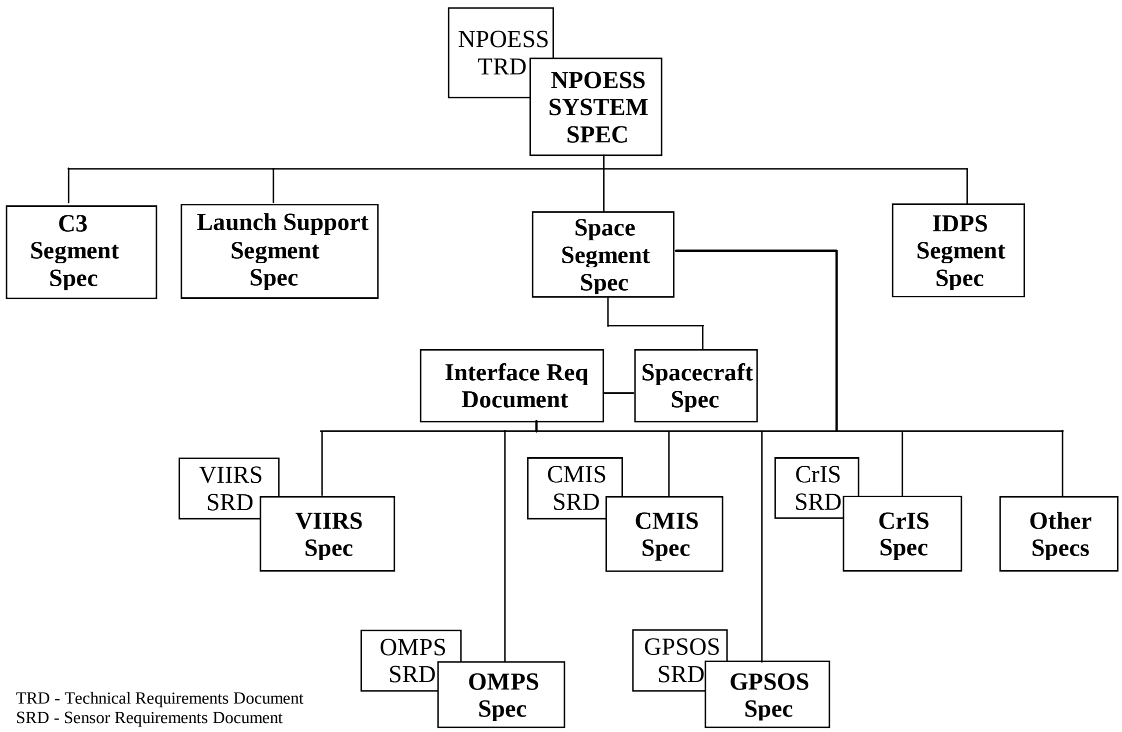

Figure 3.1.3 Partial Specification Tree

3.1.4 TOP-LEVEL SENSOR FUNCTIONS

SRDK3.1.4-1
The CrIS sensor shall measure emission from the Earth and the Earth's atmosphere in the infrared, provide calibration for these data, and provide (TBD) data for the NPOESS measurement missions.

3.1.5 COMMON SENSOR MODES

The OFF, OPERATIONAL, DIAGNOSTIC, and SAFE HOLD modes are common to all NPOESS mission critical sensors.

3.1.5.1 OFF Mode

SRDK3.1.5.1-1
In the sensor OFF mode, no power shall be supplied to the sensor.

3.1.5.2 OPERATIONAL Mode

SRDK3.1.5.2-1
In the OPERATIONAL mode, the CrIS shall be in its full functional configuration.

SRDK3.1.5.2-2
In this mode, Earth scene radiance, calibration, and housekeeping data shall be acquired.

3.1.5.3 DIAGNOSTIC Mode

SRDK3.1.5.3-1
The sensor DIAGNOSTIC mode shall support housekeeping and software updates.

SRDK3.1.5.3-2
The DIAGNOSTIC mode shall support trouble shooting.

3.1.5.4 SAFE HOLD Mode

In the SAFE HOLD mode, health and status data are collected and transmitted. Mission and calibration data are not collected.

SRDK3.1.5.4-1
The SAFE HOLD mode is a power conservation mode. The sensor shall accept a command in the event the spacecraft enters an anomalous configuration or orientation as determined by the spacecraft computer. A power subsystem anomaly is such an event.

SRDK3.1.5.4-2
The spacecraft C&DH will issue power conservation re-configuration commands to the sensors, via the data bus, that will place the sensor in a safe configuration. The return to the OPERATIONAL mode shall require ground intervention.

SRDK3.1.5.4-3
In this mode most components shall be turned off, with survival heaters activated.

3.1.5.5 CrIS Specific Sensor Modes (TBR)

SRDK3.1.5.5-1
The CrIS contractor shall recommend to the Government additional CrIS-specific modes. The recommended modes may include System Test Mode, Storage Mode, Transport Mode, Pre-launch Mode, Launch and Ascent Mode, Deployment and Initialization Mode, and Calibration and Validation Mode.

3.1.6 OPERATIONAL AND ORGANIZATIONAL CONCEPT

3.1.6.1 Expendable Launch Vehicle Concept N/A

3.1.6.2 Launch Operations Concept

3.1.6.2.1 Pre-launch

The CrIS sensors will be delivered and integrated onto the specified satellite platforms.

SRDK3.1.6.2.1-1
During integration, various CrIS verification tests shall be required.

3.1.6.2.2 Launch

During launch and injection to the operational orbit, the CrIS subsystems may be powered on or turned off in order to provide protection from the launch and injection environments or to comply with other specified requirements. Spacecraft telemetry to monitor sensor status will be provided during launch and injection. Spacecraft telemetry transmission to ground monitoring stations would be used to the extent practicable during the injection phase. After insertion into its operational orbit and separation from the launch vehicle, appropriate deployments would be initiated by memory command and/or ground command. Early orbit check-out will be conducted at the NPOESS primary SOC in Suitland, MD.

SRDK3.1.6.2.2-1
All CrIS specific requirements for power, telemetry, and (TBD) needed during launch shall be identified by the contractor.

3.1.6.3 On-orbit Operational Concept

The NPOESS satellite will operate in a near circular, sun-synchronous orbit. The nominal orbit for the spacecraft is 833 km altitude, 98.7 degree inclination. The orbit will be a "precise" orbit (i.e., altitude maintained to ± 17 (TBR) km, ± 0.05 (TBR) degrees inclination, nodal crossing times maintained to ± 10 minutes throughout the mission lifetime) to minimize orbital drift (precession). NPOESS must be capable of flying at any equatorial node crossing time. However, the nominal configuration is with the satellite orbits equally spaced, with 0530 and 1330 nodal crossing times for the U.S. Government satellites and 2130 for the METOP spacecraft.

SRDK3.1.6.3-1
The CrIS instrument design shall be such that data acquisition and necessary calibrations can be completed if the satellite is flown in the above defined orbit with anyl equatorial node crossing time (ascending or descending).

SRDK3.1.6.3-2
Not Used.

SRDK3.1.6.3-3

Specified EDR performance shall be obtained for any of the orbits in SRDK3.1.6.3-1, except for the restrictions in SRDK3.1.6.3-4.

SRDK3.1.6.3-4

The satellite shall only be flown in orbits that keep sunlight off of the cold side of the spacecraft. Because of natural variations in orbit, the 10 minute nodal crossing time constraint, and variations in the solar illumination of the satellite, this will restrict the spacecraft from flying in orbits within about 30 (TBR on satellite contractor) minutes of noon.

3.1.6.3.1 On-orbit Tests

The initial on-orbit period is devoted to a complete spacecraft checkout and to the calibration and performance verifications of the sensors, including the CrIS. The spacecraft and sensor performance verification tests may be repeated at appropriate times during the operational phase of the mission.

3.1.6.3.2 On-orbit Operations

The on-orbit CrIS sensors continuously perform all required measurements. Real- time data are continuously sent to the spacecraft. The CrIS sensors receive commands from the spacecraft for either execution in real time or for subsequent on-board execution.

SRDK3.1.6.3.2-1

The sensor shall be capable of operating for up to 21 days (with an objective of 60 days) without additional commands.

3.2 CRIS CHARACTERISTICS

3.2.1 EDR PERFORMANCE CHARACTERISTICS

3.2.1.1 Performance Characteristics

3.2.1.1.1 EDR Requirements

EDR requirements are broken into two categories: primary and secondary. Primary EDRs are those EDR attributes for which a sensor contractor has been assigned primary sensor and algorithm development responsibility. The algorithm may or may not require the use of additional data from other than the primary sensor. Secondary EDRs are those EDR attributes for which the sensor may provide data as a secondary input to an EDR algorithm assigned as a primary EDR to another NPOESS sensor contractor.

SRDK3.2.1.1.1-1
The modifications and clarifications of EDR Requirements in this section shall take precedence over any conflicting requirements or statements in Appendix D of the TRD or the IORD.

SRDK3.2.1.1.1-2
The contractor shall identify all sources of data required to meet threshold requirements for the primary EDRs, including data from other sensors, ancillary data sources, etc.

SRDK3.2.1.1.1-3
The contractor shall identify any multiple sensor constraints on the relationships between sensors within CrIMSS or between sensors in different sensor suites that are entailed by the contractor's algorithms for the CrIS primary EDRs which require data from multiple sensors. Such constraints might include, for example, relative pointing knowledge, relative pointing accuracy, co-boresighting, synchronization, etc. Based on this information and the corresponding information from other sensor contractors, the government may impose modified or additional requirements on the CrIS and/or other sensor suites. Secondary EDR requirements by one contractor to another shall be defined by no later than 60 days prior to SRR.

3.2.1.1.1.1 Primary EDRs (CrIS with MW CrIMSS Sensors)

This category of primary EDRs is being satisfied by the CrIS, but may be augmented by data from MW CrIMSS sensors.

The Contractor must specify the conditions under which the requirement to deliver an EDR meeting data content and quality requirements will not be met, regardless of whether it is "clear" or "cloudy". The contractor must also specify the conditions under which it would recommend delivering an EDR which is incomplete and/or degraded but which is still of potential utility to one or more users.

The following paragraphs provide supplementary clarification to the primary EDR requirements listed in this section:

Horizontal Cell Size:
A measure of the area over which a cloud free sounding is averaged, and may be represented as its square root. [The intent being that within the context of clear and cloudy profiling situations, the minimally acceptable cell size is the associated sensor Instantaneous Field of Regard (IFOR); with the implied goal being a retrieval performed at the highest resolution sensor Instantaneous Field of View (IFOV) practical.] When the IFOV is cloud-free, profiles with HCS no worse than stated SRD threshold values are expected.

Horizontal Reporting Interval:
In the case of the CrIS SRD EDR requirements, the objective for HRI is that which would result from one sounding per CrIS Instantaneous Field of View (IFOV). The threshold for HRI is that which would result from one sounding report per Instantaneous Field of Regard (IFOR). Depending on cloud conditions, sounding HRIs may range from one per IFOV in cloud free to one per IFOR in extremely (>50%) cloudy conditions. This reporting interval will naturally increase from nadir to edge of scan.

Vertical Cell Size:
The vertical distance over which the accuracy of the average value of the profile/parameter must meet associated EDR measurement uncertainty requirements [as listed in appropriate EDR performance tables in this section].

Vertical Reporting Interval:
The distance between reports, where each report represents values at discrete points. There must be at least 4 reports available [at a minimum] to construct an average value of the profile over the vertical cell size up to 1 mb.

SRDK3.2.1.1.1.1-1
At a minimum, the threshold requirements for the following primary EDRs shall be satisfied by the CrIS in conjunction with potential CrIMSS sensors.

Atmospheric Vertical Moisture Profile TRD Appendix D Section 40.2.1

Note: Supplemental information concerning conventions/general EDR requirements can be found in Section 40.1 of Appendix D of the TRD and are to be followed unless found to be in conflict with modifications and clarifications of EDR requirements identified in this section. The specific EDR attribute values identified below over-ride the corresponding EDR attribute values as cited in Section 40.2.1 of Appendix D of the TRD.

An atmospheric vertical moisture profile is a set of estimates of average mixing ratio in three-dimensional cells centered on specified points along a local vertical. For this EDR, horizontal cell size is specified at nadir only. The mixing ratio of a sample of air is the ratio of the mass of water vapor in the sample to the mass of dry air in the sample. Clear refers to cases in which the average fractional cloudiness in the array of CrIS spots falling within an "AMSU-A like" footprint is up to 50%. The instrument shall be capable of meeting sounding requirements in situations where none of the individual spots **is cloud-free**. The sounding requirements represent errors in a given layer. There is no requirement that errors in adjacent layers be uncorrelated.

The attribute numbering in the tables below is consistent with Appendix D of the TRD except for the preface letter which indicates it is under a unique requirement in this SRD. Any difference in these attributes takes precedence over Appendix D of the TRD values as they reflect an intentional requirements allocation to this sensor.

Units: g/kg

Para. No.		Thresholds	Objectives
K40.2.1-1	a. Horizontal Cell Size	15 km @ nadir	2 km @ nadir
K40.2.1-2	b. Horizontal Reporting Interval	(TBD)	(TBD)
K40.2.1-3	c. Vertical Cell Size	2 km	2 km
	d. Vertical Reporting Interval		
K40.2.1-4	1. surface to 850 mb	20 mb	5 mb
K40.2.1-5	2. 850 mb to 100 mb	50 mb	15 mb
K40.2.1-6	e. Horizontal Coverage	N/A*	N/A*
K40.2.1-7	f. Vertical Coverage	Surface to 100 mb	Surface to 100 mb
K40.2.1-8	g. Measurement Range	0 - 30 g/kg	0 – 30 g/kg
	h. Measurement Uncertainty (expressed as a percent of average mixing ratio in 2 km layers)		
	Clear ($\leq$ 50% cloudy)		
K40.2.1-9	1. surface to 600 mb	15% or 0.2g/kg (TBR)	10%
K40.2.1-10	2. 600 mb to 300 mb	20% or 0.1g/kg (TBR)	10%
K40.2.1-11	3. 300 mb to 100 mb	25% or 0.1g/kg (TBR)	10%
	Cloudy		
K40.2.1-12	4. surface to 600 mb	20% or 0.2g/kg (TBR)	10%
K40.2.1-13	5. 600 mb to 300 mb	40% or 0.1g/kg (TBR)	10%
K40.2.1-14	6. 300 mb to 100 mb	40% or 0.1g/kg (TBR)	10%
K40.2.1-15	i. Mapping Uncertainty		
	j. Deleted		
	k. Deleted		
K40.2.1-16	l. Minimum Ground Swath-width (833 km, circular, polar-orbit altitude)	2,200 km (TBR) See*	(TBD)

* Horizontal Coverage is a system level specification determined by the number of satellites, orbitology, and sensor swath width. Thus, only "Minimum Ground Swath-width" is specified at the sensor level.

Atmospheric Vertical Temperature Profile TRD Appendix D Section 40.2.2

Note: Supplemental information concerning conventions/general EDR requirements can be found in Section 40.1 of Appendix D of the TRD and are to be followed unless found to be in conflict with modifications and clarifications of EDR requirements identified in this section. The specific EDR attribute values identified below over-ride the corresponding EDR attribute values as cited in Section 40.2.2 of Appendix D.

An atmospheric temperature profile is a set of estimates of the average atmospheric temperature in three-dimensional cells centered on specified points along a local vertical. Clear refers to cases in which the average fractional cloudiness in the array of CrIS spots falling within an "AMSU-A like" footprint is up to 50%. The instrument shall be capable of meeting sounding requirements in situations where none of the individual spots **is cloud-free**. The sounding requirements represent errors in a given layer. There is no requirement that errors in adjacent layers be uncorrelated.

Units: K

Para. No.		Thresholds	Objectives
	a. Horizontal Cell Size		
K40.2.2-1	1. Clear, nadir	18.5 km	5 km
K40.2.2-2	2. Clear, worst case	100 km	(TBD)
K40.2.2-3	3. Cloudy, nadir	48 km (TBR)	5 km
K40.2.2-4	4. Cloudy, worst case	160 km (TBR)	(TBD)
K40.2.2-5	b. Horizontal Reporting Interval	(TBD)	(TBD)
	c. Vertical Cell Size		
	Clear ($\leq$ 50% cloudy)		
K40.2.2-6	1. Surface to 300 mb	1 km	(TBD)
K40.2.2-7	2. 300 mb to 30 mb	3 km	(TBD)
K40.2.2-8	3. 30 mb to 1 mb	5 km	(TBD)
K40.2.2-9	4. 1 mb to 0.01 mb	5 km (TBR)	(TBD)
	Cloudy		
K40.2.2-10	5. Surface to 700 mb	1 km	(TBD)
K40.2.2-11	6. 700 mb to 300mb	1 km	(TBD)
K40.2.2-12	7. 300 mb to 30 mb	3 km	(TBD)
K40.2.2-13	8. 30 mb to 1 mb	5 km	(TBD)
K40.2.2-14	9. 1 mb to 0.01 mb	5 km (TBR)	(TBD)
	d. Vertical Reporting Interval		
K40.2.2-15	1. Surface to 850 mb	20 mb	15 mb
K40.2.2-16	2. 850 mb to 300 mb	50 mb	15 mb
K40.2.2-17	3. 300 mb to 100 mb	25 mb	15 mb
K40.2.2-18	4. 100 mb to 10 mb	20 mb	10 mb
K40.2.2-19	5. 10 mb to 1 mb	2 mb	1 mb
K40.2.2-20	6. 1 mb to 0.1 mb	0.2 mb	0.1 mb
K40.2.2-21	7. 0.1 mb to 0.01 mb	0.02 mb (TBR)	0.01 mb (TBR)
K40.2.2-22	e. Horizontal Coverage	N/A**	N/A**
K40.2.2-23	f. Vertical Coverage	Surface to 0.01 mb (TBR)	Surface to 0.01 mb (TBR)
K40.2.2-24	g. Measurement Range	180 - 335 K (TBR)	(TBD)
K40.2.2-25	Not used		
	h. Measurement Uncertainty		
	Clear ($\leq$ 50% cloudy)		
K40.2.2-26	1. Surface to 300 mb	1.0 K / 1 km layers	0.5K / 1km
K40.2.2-27	2. 300 mb to 30 mb	1.0 K / 3 km layers	0.5K / 1km
K40.2.2-28	3. 30 mb to 1 mb	1.5 K / 5 km layers	0.5K / 1km
K40.2.2-29	4. 1 mb to 0.01 mb*	3.5 K / 5 km layers (TBR)	0.5K / 1km (TBR)
	Cloudy		
K40.2.2-30	5. Surface to 700 mb	2.5 K / 1 km layers	0.5K / 1km
K40.2.2-31	6. 700 mb to 300 mb	1.5 K / 1 km layers	0.5K / 1km
K40.2.2-32	7. 300 mb to 30 mb	1.5 K / 3 km layers	0.5K / 1km
K40.2.2-33	8. 30 mb to 1 mb	1.5 K / 5 km layer	0.5K / 1km
K40.2.2-34	9. 1 mb to 0.01 mb	3.5 K / 5 km layers (TBR)	0.5K / 1km (TBR)
K40.2.2-35	i. Mapping Uncertainty	5 km	1 km
	j./k. Deleted		
K40.2.2-36	l. Minimum Ground Swath-width (833 km, circular, polar-orbit altitude)	2,200 km (TBR) See**	(TBD)

Measurement Uncertainty as specified in K40.2.2-29 shall be referenced to the Cloudy Horizontal Cell Size thresholds and objectives as listed under K40.2.2-3 and K40.2.2-4.

** Horizontal Coverage is a system level specification determined by the number of satellites, orbitology, and sensor swath width. Thus, only “Minimum Ground Swath-width” is specified at the sensor level.

Pressure (Surface/Profile) TRD Appendix D Section 40.3.5

Note: Supplemental information concerning conventions/general EDR requirements can be found in Section 40.1 of Appendix D of the TRD and are to be followed unless found to be in conflict with modifications and clarifications of EDR requirements identified in this section. The specific EDR attribute values identified below over-ride the corresponding EDR attribute values as cited in Section 40.3.5 of Appendix D.

A pressure profile is a set of estimates of the atmospheric pressure at specified altitudes above the Earth's surface. The requirements below apply under both clear and cloudy conditions. Pressure is assumed to be a derived quantity. The pressure profile is derived from the temperature and moisture profile as well as an external estimate of pressure at some level in the atmosphere.

Units: mb

Para. No.		Thresholds	Objectives
K40.3.5-1	a. Horizontal Cell Size	55 km (TBR)	5 km
K40.3.5-2	b. Horizontal Reporting Interval	(TBD)	(TBD)
K40.3.5-3	c. Vertical Cell Size	1 km	0 km
	d. Vertical Reporting Interval		
K40.3.5-4	1. 0 - 2 km	1 km	0.25 km
K40.3.5-5	2. 2 - 5 km	1 km	0.5 km
K40.3.5-6	3. > 5 km	1 km	1 km
K40.3.5-7	e. Horizontal Coverage	N/A*	N/A*
K40.3.5-8	f. Vertical Coverage	0 – 30 km	0 - 30 km
K40.3.5-9	g. Measurement Range	10 – 1050 mb	10 - 1050 mb
	h. Measurement Accuracy		
K40.3.5-10	1. 0 - 2 km	1 % (TBR)	(TBD)
K40.3.5-11	2. 2 - 10 km	1 % or or 10 mb (TBR)	0.5 % (TBR)
K40.3.5-12	3. 10 - 30 km	1 % or or 1 mb (TBR)	0.5 % (TBR)
K40.3.5-13	i. Measurement Precision	4 mb	2 mb
K40.3.5-14	j. Mapping Uncertainty	7 km	1 km
	k. Deleted		
	l. Deleted		
K40.3.5-15	m. Minimum Ground Swath-width (833 km, circular, polar-orbit altitude)	2,200 km (TBR) See*	(TBD)

* Horizontal Coverage is a system level specification determined by the number of satellites, orbitology, and sensor swath width. Thus, only "Minimum Ground Swath-width" is specified at the sensor level.

3.2.1.1.1.2 Primary EDRs (CrIS with MW CrIMSS and/or Other Sensors)

This category of primary EDRs is to be satisfied by the CrIS, but may be augmented by data from MW CrIMSS sensors and/or other NPOESS sensor suites identified by the contractor. These EDR requirements are (TBD).

3.2.1.1.1.3 Secondary EDRs

Secondary EDRs are EDRS that might require data from the CrIS as an input to other NPOESS sensor suites. These requirements are (TBS).

3.2.1.1.2 Operational Sensor Data Record (SDR) Requirements

In processing RDRs into EDRs, the IDPS will generate intermediate-level satellite instrument data files, including Sensor Data Records (SDRs). SDRs are needed for retrospective processing, leading to improved methods, and for archival, for long-term sensor evaluation or troubleshooting. SDRs will be delivered to the same user destinations as the associated EDRs, as specified in the EDR/RDR matrix (Appendix E), which lists delivery destinations of RDRs/EDRs. The generation and delivery of operational SDRs will be the responsibility of the Interface Data Processing Segment (IDPS) Total System Performance Responsibility (TSPR) contractor, not the CrIS contractor.

3.2.1.1.2.1 Definition

Sensor Data Records (SDRs) are full resolution sensor data that are time referenced, Earth located, and calibrated by applying the ancillary information, including radiometric and geometric calibration coefficients and georeferencing parameters such as platform ephemeris. These data are processed to sensor units (e.g., radiance). Calibration, ephemeris, and any other ancillary data necessary to convert the sensor data back to sensor raw data (counts) are included.

3.2.1.1.2.2 Content (TBR)

The operational SDR should, at a minimum, consist of the following information:

- Spacecraft ID tag
- CrIS sensor ID or serial number
- Flight software version number
- Orbit number
- Beginning Julian day and time tag
- Ending Julian day and time tag
- Ascending Node Julian day and time tag
- Spectral radiance in all channels
- Signal levels from all visible detectors.
- Geolocation: geodetic latitude and longitude for each sample
- Time tag information - beginning of scan time
- Scan index

The IDPS (TSPR) contractor, not the CrIS contractor, will be responsible for defining the content of operational SDRs.
The CrIS contractor may recommend the content of operational SDRs. The government, at its discretion, may provide this recommendation to the IDPS (TSPR) contractor.

SRDK3.2.1.1.2.2-1
The CrIS contractor shall participate in technical interchange meetings with the IDPS (TSPR) contractor to support the definition of the operational SDRs with respect to both content and format, if so requested by the government.
The CrIS contractor will determine the content of SDRs generated by the contractor for requirements validation purposes.

3.2.1.1.2.2.1 Earth Location Requirements

SRDK3.2.1.1.2.2.1-1
The sensor shall be capable of allowing the EDR Earth location requirements of 5 km mapping uncertainty for moisture profile measurements and 5 km for temperature profile measurements.

SRDK3.2.1.1.2.2.1-2
Mapping uncertainty requirements shall be consistent with the allocations for the spacecraft given in Section 3.2.4.2.1.3. Mapping Uncertainty (as defined in Appendix A, Glossary) is the Root Mean Square (RMS) error (one sigma) in the geolocation of measured or derived data samples, expressed in geodetic coordinates, based on a large number of repetitions of the measurement and/or derivation under identical conditions. An “error” is defined as the difference between the measured or derived value and the true value of a parameter. Mapping uncertainty is due to the combined effect of all systematic and random errors affecting geolocation.

SRDK3.2.1.1.2.2.1-3
The CrIS shall support the mapping uncertainty requirements of all EDRs to which it contributes.

3.2.1.1.3 RDR Requirements (TBR)

3.2.1.1.3.1 Definition

Because RDRs are processed into EDRs, RDRs are considered to have met their requirements when they are of an appropriate format and quality to be adequately processed into their associated EDRs (i.e., the contractor is responsible for insuring that RDRs support EDR quality. The instrument supplier should determine data content for data that is supplied to the satellite. Quality is that which is adequate to produce EDRs at the threshold level as specified in 3.2.1.1.1.).

SRDK3.2.1.1.3.1-1
The CrIS contractor shall be responsible for generating operational RDRs.

3.2.1.1.3.2 Content

SRDK3.2.1.1.3.2-1
The operational RDR shall at minimum consist of the following information(TBR):

- Spacecraft ID tag
- CrIS sensor ID or serial number
- Flight software version number
- Orbit number
- Beginning Julian day and time tag
- Ending Julian day and time tag
- Ascending Node Julian day and time tag
- Raw data counts
- Satellite ephemeris data sufficient to geolocate each data sample
- Time tag information - beginning of scan time
- Scan index
- Sensor calibration data: allow computation of calibration coefficients and sensitivity (ΔT_{rms}) values
- Sensor health and status data: limited to that necessary to assess performance
- CrIS mounting offset angles - need for geolocation

3.2.1.1.4 Algorithms

SRDK3.2.1.1.4-1
The contractor shall adopt or adapt existing algorithms or develop new scientific algorithms for all primary EDRs. (See Section 3.2.1.1.1.) Adopting an algorithm means using an existing algorithm without change. Adapting an algorithm means using an existing algorithm with some modification, such as different values of coefficients, inclusion of higher order corrections, fusion of additional data sources, etc.

SRDK3.2.1.1.4-2
The EDR scientific algorithms shall, when used on CrIS data in conjunction with data from the microwave component of CrIMSS, provide EDRs that satisfy the requirements of Section 3.2.1.1.1.

SRDK3.2.1.1.4-3
The contractor shall also adopt or adapt existing algorithms or develop new scientific algorithms for all intermediate level data products used to generate the primary EDRs, such as SDRs and flags indicating data quality, clear versus cloudy, etc. Because the CrIS contractor is not responsible for the content or format of operational SDRs, the CrIS contractor may select the appropriate intermediate-level data products needed as inputs to his scientific EDR algorithms in satisfying this requirement. The description of operational SDRs in Section 3.2.1.1.2.2 is provided as guidance. Algorithms need not be provided for data products that are generated by other sensor suites and utilized as inputs to the algorithms for CrIS primary EDRs.

SRDK3.2.1.1.4-4
The contractor shall also identify use of any auxiliary data. The government's Operational Algorithm Teams (OATs), may also recommend science algorithms. These teams have contributed to the definition of the instrument requirements of Section 3. The OATs may also provide advisory information on CrIS functional and calibration requirements.

SRDK3.2.1.1.4-5
The performance of the scientific EDR algorithms delivered by the CrIS contractor shall meet EDR thresholds and shall be no worse than the performance of algorithms utilized for current (TBR) operational data products for these EDRs, if such operational products exist.

SRDK3.2.1.1.4-6
The contractor shall identify and quantify any EDR algorithm performance degradation resulting from the lack of any database or other ancillary data.

SRDK3.2.1.1.4-7
The Contractor shall develop sufficient materials for an Algorithm Theoretical Basis Document (ATBD) for the assigned set of primary EDRs. ATBDs provide the physical theory and assumptions behind the EDRs, as well as the mathematical procedures required to produce the RDRs, convert the RDRs into the SDRs, and convert the SDRs into the EDRs. The ATBD should discuss limitations on the approach, accuracy considerations, additional information required for measurement processing (mandatory and desirable), and alternative processing approaches required under alternative measurement situations (e.g., daytime and nighttime observations).

SRDK3.2.1.1.4-8
The Contractor shall develop sufficient research grade source code for implementing the algorithm(s) described in the ATBD that address the primary EDRs. The research grade code should include all processes, other than input/output, needed to: convert RDRs into SDRs; convert SDRs into EDRs; use all mandatory outside data; use any optional outside data, if available; select alternative processing algorithms based on the data available; provide continuing calibration validation; and any other similar processing tasks required to satisfy allocated EDR quality and availability requirements. The scientific algorithms developed by the contractor may be adopted or adapted from existing algorithms, or developed, as needed.

3.2.1.1.4.1 Convertibility to Operational Code

The government considers the SDR and EDR algorithms adopted, adapted, or developed by the CrIS contractor to be scientific, rather than operational, algorithms. The CrIS contractor is not responsible for identifying or developing operational SDR and EDR algorithms for the CrIS. (Any operational algorithms necessary for the generation of RDRs will ultimately be the responsibility of the CrIS contractor, and the operational code implementing these algorithms will be part of the required flight software. This statement applies to the post-downselect phase of the CrIS program.)

SRDK3.2.1.1.4.1-1
The scientific SDR and EDR algorithms delivered by the CrIS contractor shall be convertible into operational code that is compatible with a 20 minute maximum processing time at either the DoD Centrals or DoD field terminals for the conversion of all pertinent RDRs into all required EDRs for the site or terminal, including those based wholly or in part on data from other sensor suites. The intent of this requirement is to preclude algorithms that are so computationally intensive that any foreseeable implementation would stress or exceed the time available for delivery of EDRs in an operational environment.

SRDK3.2.1.1.4.1-2
The means by which the contractor shall validate the requirement that scientific algorithms be convertible to operational code subject to the constraint specified in SRDK3.2.1.1.4.1-1 is (TBR).

SRDK3.2.1.1.4.1-3
The availability of any inputs required from databases or other ancillary sources to generate data products shall also be adequate to allow EDRs to be generated at the DoD Centrals and DoD field terminals within the time constraint specified in SRDK3.2.1.1.4.1-1.

3.2.1.2 Mission Sensor Calibration (TBS)

3.2.1.3 Data Formatting and Compression

SRDK3.2.1.3-1
The data packets generated by the CrIS shall conform to the Consultative Committee for Space Data Systems (CCSDS) packetization per the real-time and stored data specifications referenced in SRD Sections 3.2.4.8.2 and 3.2.4.9.4.

SRDK3.2.1.3-2
If data compression techniques are utilized by the CrIS in generating data packets for storage on-orbit, the compression shall be lossless.

3.2.1.4 Spectral Band

A spectral band is defined as the radiometric pass band of the scene radiance for a single detector or group of detectors.

SRDK3.2.1.4-1
Multiple spectral bands shall be contained in the entire spectral range of the CrIS.

3.2.1.5 Number of Spectral Bands

The number of spectral bands will be the minimum required to meet all sensitivity requirements.

SRDK3.2.1.5-1
There shall be a minimum of (TBD) bands spanning a spectral range defined notionally in paragraph 3.2.1.18.

3.2.1.6 to 3.2.1.17 Not Used

3.2.1.18 Spectral Range

(TBD). The minimum notional spectral range is defined in Table 3.2.1.18. The spectral resolution in each band should be sufficient to meet the EDR requirements. Note: A TBD visible band is also suggested for cloud clearing purposes.

Table 3.2.1.18 Notional Spectral Resolution

	Wavenumber Range (cm-1)	Wavelength Range (microns)	Maximum OPD (cm)	Unapodized Resolution (cm-1)
Band 1	635-1095	9.13-15.75	TBD	TBD
Band 2	1210-1600	6.25-8.26	TBD	TBD
Band 3	2155-2800	3.57-4.64	TBD	TBD

3.2.1.19 Number of Detectors in the Field of Regard

The field of regard will have TBD fields-of-view (FOV) spaced as shown notionally in the Figure 3.2.1.19 below. In each band, a separate detector is associated with each FOV. There shall be no significant differences in calibrated observations obtained from different detectors.

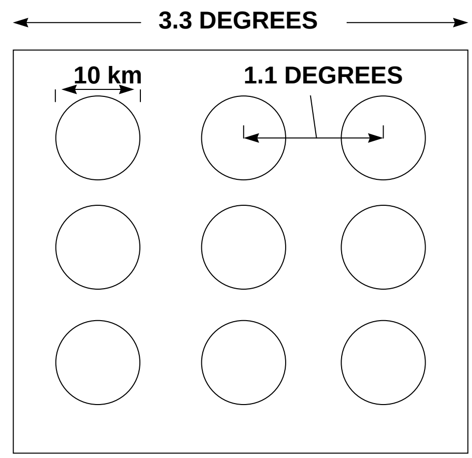

Figure 3.2.1.19 Field of Regard (Notional Layout for Nine Detector Case)

3.2.1.20 Wavenumbers in a Spectral Band

There is no unique set of wavenumbers for an interferometer. The radiance spectrum obtained from the cosine transform of the sampled interferogram is continuous and well defined at all wavenumbers in the band.

3.2.1.20.1 Number of Wavenumber Channels in the Band

A fast Fourier transform (FFT) of a sampled interferogram provides a set of spectral radiances uniformly spaced by the wavenumber step size across the band.

SRDK3.2.1.20.1-1
The spectral response at any wavenumber in the band shall be obtained by interpolating between these wavenumber values.

3.2.1.20.2 Aliasing

SRDK3.2.1.20.2-1
The analog interferogram signal shall be appropriately filtered to minimize noise aliasing after sampling.

SRDK3.2.1.20.2-2
The filter design shall minimize gain and phase variation in the signal bandpass caused by any moving mirror velocity variations. This potential noise should be addressed in the noise performance estimates of section 3.2.1.25.

3.2.1.20.3 Wavenumber Step Size

The wavenumber step size (dν) between spectral data points is defined as the reciprocal of the optical path difference (OPD) between the first and last samples of the sampled interferogram. For an N-point sample set, (OPD_N - OPD_1) = (N - 1) dx and dν = 1/((N - 1) dx), where: dν is the wavenumber step size and dx is the OPD spacing between interferogram samples, typically determined by the reference laser. The wavenumber step size will vary with off-axis field angle and each FOV must be appropriately compensated.
The wavenumber step size should not be confused with the spectral resolution.

SRDK3.2.1.20.3-1
The wavenumber step size shall be accurately determined to 5 parts in 10^6 for all FOVs.

3.2.1.20.4 Unapodized Spectral Resolution

The unapodized spectral resolution is defined as the reciprocal of the maximum optical path difference, i.e., if the Optical Path Difference (OPD) change is ± L, the total double-sided maximum OPD change is 2L and the wavenumber step size is 1/(2L).

3.2.1.21 Retrieval Spectral Channel Wavenumbers

A (TBR) set of nominal retrieval spectral channel wavenumbers should be provided.

SRDK3.2.1.21-1
Radiance data from all detectors shall be interpolated to this standard set of spectral channel wavenumbers for retrieval studies and other EDR validations.

3.2.1.22 Dynamic Range

The dynamic range of the instrument should allow for the required sensitivity over a range of nominal scenes and calibration targets, including a space look.

3.2.1.23 System Linearity

SRDK3.2.1.23-1
The nonlinearity of specific spectral bands across the instruments' dynamic range shall be measured and demonstrated to be stable enough to meet all radiometric requirements.

3.2.1.24 Quantization (TBD)

3.2.1.25 Noise-Equivalent Temperature Difference/Noise-Equivalent Radiance Difference

3.2.1.25.1 Definition

The noise performance requirements are defined at the aperture of the system by the noise-equivalent radiance difference (NEdN) arriving from the top of the atmosphere (TOA). The noise-equivalent temperature difference (NEdT) at a given wavenumber is defined by dividing the NEdN at that wavenumber by the derivative with respect to temperature of the Planck black body radiance function, evaluated at 250 degrees K at the same wavenumber.

3.2.1.25.2 Standard Earth Scenes

The NPOESS IPO shall provide sounder data sets for use by the Contractor in evaluating sensor designs, and in verifying sensor suite and algorithm performance. The government will create an additional set of sounder data with the intent to conduct a “blind test” performed by the Contractor. If available, these blind test results will be briefed to the Government either prior to or at PDR (at the Contractor’s discretion. The sounder data sets will consist, as a minimum, of the following items:

1) NOAA 88 atmospheric profiles data set
2) OPTRAN microwave Rapid Transmittance Algorithm
3) CrIS Weather Products Test Bed Rapid Transmittance Algorithm
4) AIRS one-orbit data set
5) Blind Test Set

3.2.1.25.3 Earth Scene Variation

The noise performance for the instrument will depend on the Earth scene. The following Earth scenes are representative of the extremes in Earth radiance. The interferometer noise will depend on the broad band integrated flux. The blackbody temperatures for equivalent in-band scenes' radiances are given in Table 3.2.1.25.3. The radiance levels are plotted in figures 3.2.1.25.3-1 through -4.

Table 3.2.1.25.3 Blackbody Temperatures for Equivalent In-band Scene Radiances.

		Hot (K)	Nominal (K)	Cool (K)
Band 1	635 - 1095	**281**	**264**	**233**
Band 2	1210-1540	**273**	**254**	**234**
Band 3	2155-2450	**287**	**269**	**233**

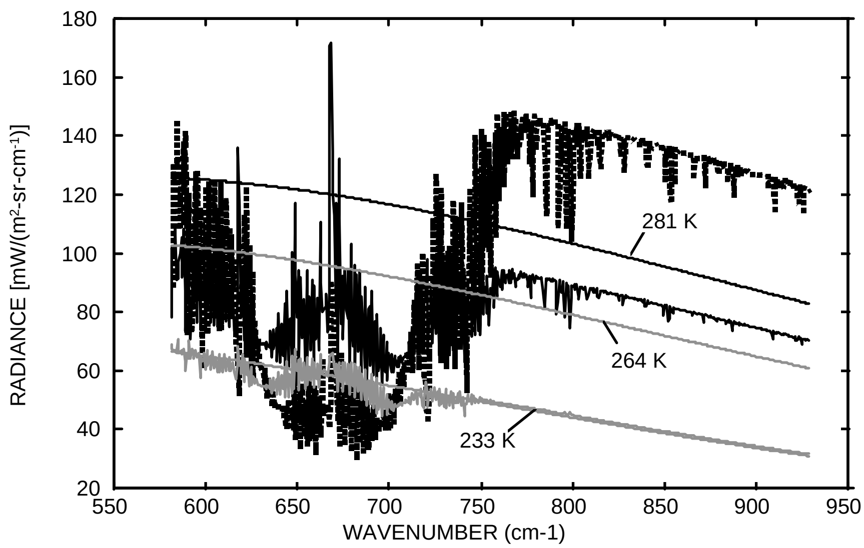

Figure 3.2.1.25.3-1 Three Earth Radiance Profiles for the Long-wavelength Band

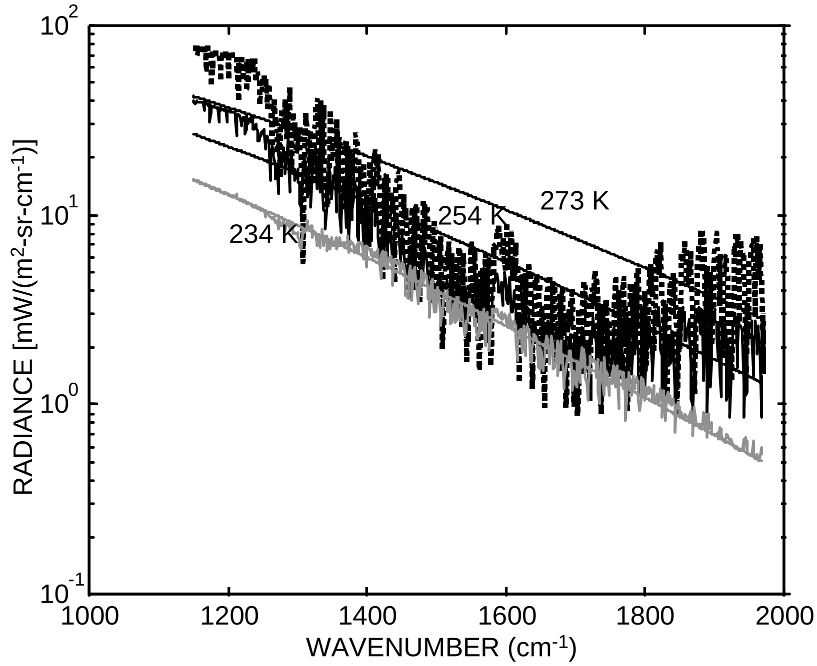

Figure 3.2.1.25.3-2 Three Earth Radiance Profiles for the Mid-wavelength Band

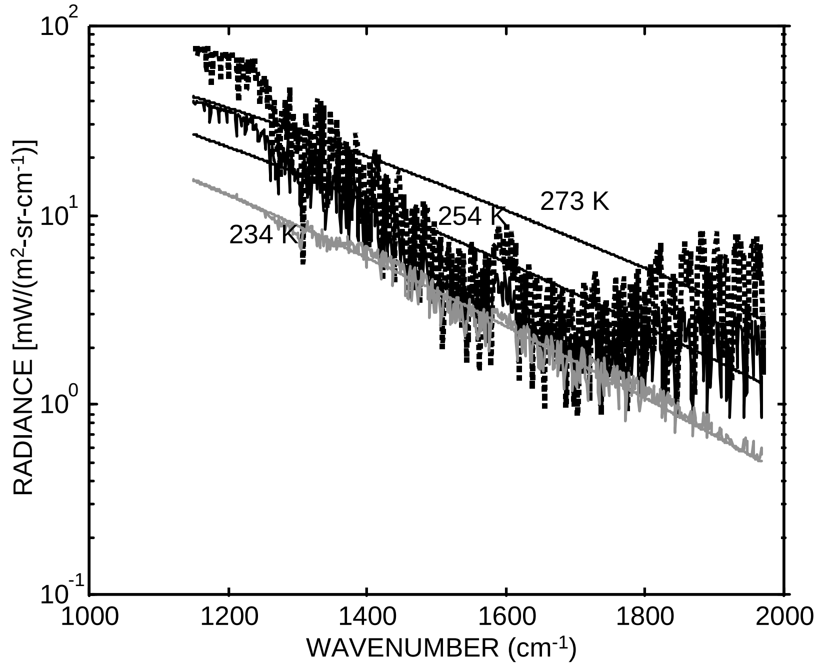

Figure 3.2.1.25.3-3 Three Earth Radiance Profiles for the Short-wavelength Band

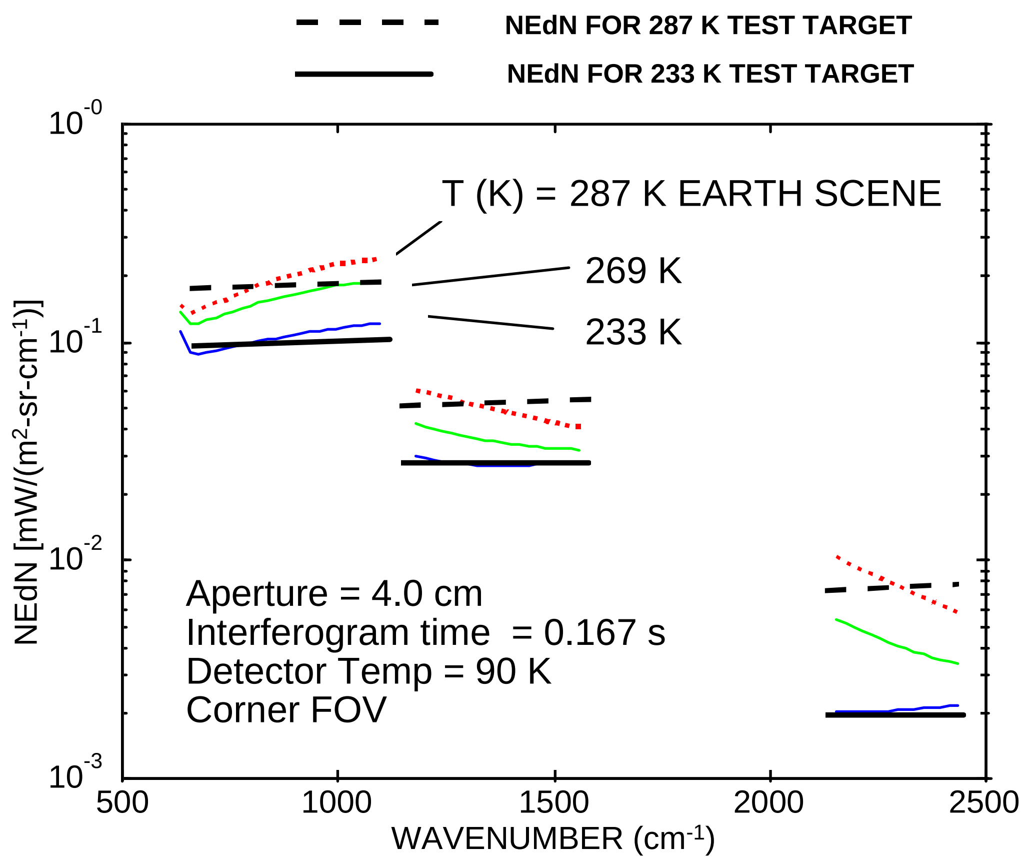

Figure 3.2.1.25.3-4 Nominal Estimated Earth Scene NEdN for Point Design and Maximum Allowable NEdN for Blackbody Test Targets.

3.2.1.25.4 Noise Performance

SRDK3.2.1.25.4-1
The CrIS shall be designed to provide data to meet the EDR requirements. The maximum (TBR) allowed NEDN values are tabulated in Table 3.2.1.25.4. NEDN values should be sufficiently low to ensure EDR requirements are satisfied.

Table 3.2.1.25.4 Maximum (TBR) Allowed NEdN [mW/(m^2-sr-cm^{-1})]

TEST TARGET TEMPERATURE		T = 287 K	T = 233 K
WAVENUMBER RANGE (cm-1)	BIN SIZE (cm-1)	NEDN	NEDN
650-900	0.625	0.17 (TBR)	0.10 (TBR)
900-1100	0.625	0.25 (TBR)	0.13 (TBR)
1210-1540	1.25	0.06 (TBR)	.03 (TBR)
2155-2400	2.50	0.008 (TBR)	0.002 (TBR)

3.2.1.26 Absolute Radiometric Accuracy, Precision, and Repeatability

The following items reflect anticipated CrIS sensor on-orbit performance characteristics to be verified prior to flight through ground test(s).

3.2.1.26.1 Absolute Radiometric Accuracy

The absolute radiometric accuracy is the estimate of the bound of the unknown bias error of the calibration process root-mean-squared with any random precision or repeatability component in a specific measurement period.

SRDK3.2.1.26.1-1
The manufacturer shall develop a detailed radiometric error analysis of the instrument, calibration sources, and calibration procedures; minimize errors in traceability to absolute National Institute of Standards and Technology (NIST) standards; and estimate the bound on such errors.

SRDK3.2.1.26.1-2
The radiometric error analysis shall include:

1. Quantization Noise
2. G-r noise (thermal and photon)
3. Sampling time jitter
4. Johnson noise
5. Preamp noise
6. Mirror velocity jitter
7. Mirror tilt jitter
8. Aliasing noise
9. Polarization
10. Blackbody emissivity
11. Non-linearity (detector-to-detector)
12. Line shape error

SRDK3.2.1.26.1-3
The design shall reflect the absolute accuracy goal of less than 1%.

3.2.1.26.2 Unit Data Set

The unit data set is the measured spectral radiances for all channels, for specified background, mission operating conditions, and time period.

SRDK3.2.1.26.2-1
The sample size of the unit data set shall be no less than 512 (TBR) contiguous samples per spectral channel, taken from 512 (TBR) successive processed interferograms**.**

3.2.1.26.3 Precision

The radiometric precision of a wavenumber channel is the standard deviation of the spectral radiances in the unit data set for that wavenumber channel. The radiometric precision is specified by the NEDN (section 3.2.1.25).

3.2.1.26.4 Short-Term Repeatability

The short-term repeatability of a wavenumber channel is defined as the standard deviation of the means of the spectral radiances in the unit data sets for that wavenumber channel.

SRDK3.2.1.26.4-1
An ambient reference target of 287 K (TBR) shall be used to measure short-term stability.

SRDK3.2.1.26.4-2
The unit data sets from which the means are derived shall be taken every minute over a 60 (TBR) minute period.

SRDK3.2.1.26.4-3
The short-term repeatability shall be better than 0.2% (TBR).

3.2.1.26.5 Long-Term Repeatability

The long-term repeatability of a wavenumber channel is defined as the standard deviation of the means of the spectral radiances in the unit data sets for that wavenumber channel.

SRDK3.2.1.26.5-1
An ambient reference target of 287 K (TBR) shall be used to measure long-term stability.

SRDK3.2.1.26.5-2
The unit data sets from which the means are derived shall be taken at 12 hour (TBR) spacing over more than a 30 day period (TBR).

SRDK3.2.1.26.5-3
The long-term repeatability shall be better than 0.5% (TBR) of the spectral radiances in the unit data.

3.2.1.27 Channel Radiometric Noise Power Spectrum Diagnostic (TBR)

The CrIS sensor will require diagnostic ground tests.

SRDK3.2.1.27-1
The noise power spectrum of each spectral channel for each detector shall be determined to a resolution better than 1/128 Hz (TBR).

SRDK3.2.1.27-2
The required processing shall be done in near real time, independently and in parallel with any test equipment command and data taking functions.

SRDK3.2.1.27-3
The resulting interferogram shall be available for review within 15 minutes (TBR) of the completion of the data taking period.

SRDK3.2.1.27-4
Provisions shall be made to take such spectral measurements at any time by operator intervention.

SRDK3.2.1.27-5
The complete (undecimated) interferogram shall be provided for diagnostic purposes.

SRDK3.2.1.27-6
Up to four wavenumber operator-defined channels shall be displayed simultaneously.

3.2.1.28 CrIS Sensitivity Validation and Calibration

The CrIS sensor will require pre-launch (ground) and on-orbit calibration.

SRDK3.2.1.28-1
The on-orbit calibration source(s) shall be the primary calibration source(s).

3.2.1.28.1 Ambient Bench Tests (TBR)

SRDK3.2.1.28.1-1
The CrIS shall be tested under ambient conditions prior to thermal vacuum testing with the detectors cooled to mission operational levels.

SRDK3.2.1.28.1-2
These tests shall demonstrate full sensor functionality and validate the radiometric sensitivity of the CrIS over a selected range of expected on-orbit environmental conditions and instrument operational states/modes.

3.2.1.28.1.1 Calibration Source Requirements

SRDK3.2.1.28.1.1-1
Calibration/test targets suitable for producing CrIS ground scenes flux levels on the detectors shall provide for emulation ground scenes from 270 to 330 K.

3.2.1.28.1.2 Electronic Noise

SRDK3.2.1.28.1.2-1
The noise performance shall be measured with zero photon flux level on the detectors (TBR).

3.2.1.28.2 Thermal Vacuum Ground Calibration

SRDK3.2.1.28.2-1
The ground thermal vacuum calibration shall be a simulation of the on-orbit calibration.

SRDK3.2.1.28.2-2
The ground calibration shall consist of tests that will validate the radiometric accuracy of the CrIS over the range of expected on-orbit environmental conditions and instrument operational states/modes.

3.2.1.28.2.1 Test Targets

SRDK3.2.1.28.2.1-1
The brightness temperature targets shall provide references near the extremes of the expected scene brightness temperature range.

SRDK3.2.1.28.2.1-2
The calibration/test targets shall be equipped with sensors for National Institute of Standards and Technology (NIST) traceable absolute temperature and temperature uniformity measurements.

SRDK3.2.1.28.2.1-3
The absolute surface temperature knowledge shall be ± 0.1 K (TBR).

SRDK3.2.1.28.2.1-4
The uniformity shall be within ± 0.3 K (1 sigma) (TBR) of the target mean in the thermal vacuum environment.

3.2.1.28.2.2 Calibration Source Temperatures

SRDK3.2.1.28.2.2-1
Calibration/test targets suitable for all CrIS ground scenes shall be provided for at least the temperatures of (approximately and in Kelvin): 200, 240 280, 300, and 330. Cold space look targets near 77 K must be provided.

3.2.1.28.2.3 Axial Temperature Gradients

SRDK3.2.1.28.2.3-1
Temperature difference between the temperature controlled section of the target and the surface viewed by the radiometer shall be determined to ± 0.05 K (TBR) using NIST traceable measurement techniques and standards.

3.2.1.28.2.4 Surface Temperature Gradients

SRDK3.2.1.28.2.4-1
The maximum temperature difference over the surface of the calibration/test standard shall be less than 0.5 K (TBR).

3.2.1.28.2.5 Temperature Variability

The surface temperature at monitoring points on or in the calibration/test standard must be able to be held to within 0.05 K over the calibration characterization period at any chosen brightness temperatures in paragraph 3.2.1.28.2.2.

3.2.1.28.2.6 Emissivity

SRDK3.2.1.28.2.6-1
Calibration/test targets shall have a demonstrated, effective emissivity greater than 0.98 (TBR) at all wavenumbers in the band to minimize narcissus and stray reflected radiation.

SRDK3.2.1.28.2.6-2
The emissivity shall be known to 0.005 over all spectral bands.

3.2.1.28.3 On-orbit Calibration

SRDK3.2.1.28.3-1
Any external, operational calibration techniques shall not affect the normal sensing performance for scene brightness temperatures through the interferometer nor cause sun glint into the sensor, or any other NPOESS sensor.

SRDK3.2.1.28.3-2
Any external calibration system shall have view angles and other properties that are compatible with the NPOESS spacecraft and all other on-board sensors.

SRDK3.2.1.28.3-3
The calibration standards employed for on-orbit calibration of the CrIS shall provide sufficiently accurate radiometric temperature to enable the CrIS to meet radiometric accuracy requirements listed in paragraph 3.2.1.26 over the expected on-orbit environmental operating conditions of the CrIS.

SRDK3.2.1.28.3-4
The CrIS shall incorporate a calibration system that uses a minimum of two signal levels (hot and cold effective scene brightness temperatures).

SRDK3.2.1.28.3-5
The CrIS shall incorporate at least one internal warm target with a temperature range from 290 to 310 K. The cold radiance level may utilize a cold space view.

3.2.1.28.4 Onboard Calibration Frequency

SRDK3.2.1.28.4-1
The calibration target radiance in all channels shall be measured once per scan as required. A number of calibration samples taken during successive scans may be averaged to improve the calibration target signal-to-noise.

3.2.1.28.5 Onboard Target Emissivity

SRDK3.2.1.28.5-1
Calibration/test targets shall have a demonstrated, effective emissivity greater than 0.98 (TBR) at all wavenumbers in the band.

3.2.1.28.6 Onboard Target Temperature

SRDK3.2.1.28.6-1
The brightness temperature of the onboard calibration standard(s) shall provide accurate reference(s) in the temperature range 290-310 K.

3.2.1.28.7 Axial Temperature Gradients

SRDK3.2.1.28.7-1
Temperature difference between the temperature controlled section of the target and the surface viewed by the radiometer shall be measured to 0.03 K (TBR) by a one-time ground test using NIST traceable measurement techniques and standards.

3.2.1.28.8 Surface Temperature Variation

SRDK3.2.1.28.8-1
The maximum temperature difference over the surface of the calibration/test standard shall be less than 0.5 K (TBR).

3.2.1.28.9 Temperature Stability

The surface temperature at monitoring points on or in the calibration/test standard must be able to be held to within 0.05 K over the calibration characterization period at any chosen brightness temperatures.

3.2.1.29 Scan Requirements

3.2.1.29.1 Type of Scan

SRDK3.2.1.29.1-1
The CrIS shall be a cross-track, scanning sensor, with step-and-stare compensation.

3.2.1.29.2 Instantaneous Field of Regard

The CrIS Instantaneous Field of Regard (IFOR) is defined as 3.3 by 3.3 degrees (TBR).

3.2.1.29.3 In-Scan IFOR Sampling Interval

SRDK3.2.1.29.3-1
The IFOR sampling interval along the scan shall be 3.3 degrees (TBR).

3.2.1.29.4 Swath Width

SRDK3.2.1.29.4-1
The scan extent shall be the minimum required to satisfy EDR requirements in section 3.2.1.1, but no less than ± 49.5 (TBR) degrees from nadir.

3.2.1.29.5 Swath Width Repeatability

SRDK3.2.1.29.5-1
The scan shall be repeated every 3.3 degrees (TBR).

3.2.1.29.6 Scan Time

The cross track scan time is the time required to move the nadir intersection with a ground IFOR width as referenced from nadir.

3.2.1.29.7 Scan-to-Scan Separation

SRDK3.2.1.29.7-1
The Scan-to-Scan separation shall be that defined by the swath width repeatability defined in 3.2.1.29.5, as referenced from nadir.

3.2.1.29.8 Number and Types of Scan Modes

SRDK3.2.1.29.8-1
The CrIS shall have the minimal number of scan modes required to meet the EDR requirements.

3.2.1.29.9 Scan Position Knowledge

SRDK3.2.1.29.9-1
The CrIS shall provide a measurement and readout capability to determine the angular position of the CrIS LOS in the azimuth direction relative to the satellite velocity vector.

SRDK3.2.1.29.9-2
This measurement shall be accurate to (TBD) degrees and consistent with the Earth location and EDR requirements.

3.2.1.30 CrIS Spatial Resolution and Sampling

3.2.1.30.1 Detector Geometric FOV

The geometric FOV is defined as the angle subtended by the maximum dimension of the geometric ground footprint.

3.2.1.30.2 Geometric Ground Footprint

The geometric ground footprint is the geometric projection of the detector field stop onto the Earth at nadir.

3.2.1.30.3 N/A

3.2.1.30.4 FOV Modulation Transfer Function (MTF)

SRDK3.2.1.30.4-1
The shape of the angular detector FOV shall be determined by an MTF measurement at (TBS) spatial frequencies.

3.2.1.30.5 FOV Alignment

SRDK3.2.1.30.5-1
The location of each FOV footprint relative to the optical boresight shall be known to less than 5% (TBR) of the geometric FOV.

3.2.1.30.6 FOV Co-registration

SRDK3.2.1.30.6-1
The centroid of the FOV of all channels within a band and also for each band with the same nominal FOV location shall fall in a circle with a diameter equal to 3% (TBR) of the geometric FOV. The goal is for spatial areas of the scenes observed by all detectors and all channels with the same nominal FOV location to overlap by at least 97% of the area observed by a given detector. In addition, the goal is to insure that chromatic aberrations in the optical system are not so great as to cause more than 3% (TBR) of the desired spectral range to wander outside the responsive area of the respective detector.

3.2.1.31 Polarization N/A

3.2.1.32 to 3.2.1.35 Not Used

3.2.1.36 Stray Light Rejection (TBD)

3.2.1.37 Earth Location Requirements (TBR)

The alignment relative to the spacecraft, and knowledge of the CrIS Line-of-Sight (LOS), in conjunction with the spacecraft attitude and ephemeris data will allow the Earth location of the CrIS sensor data in geodetic latitude and longitude to be corrected for altitude within the accuracy specified for each EDR in Appendix D of the TRD.

3.2.1.37.1 Allocations

Refer to section 3.2.4.2.1.3 “Alignment.”

3.2.1.37.2 Sensor Reference Axes Alignment

SRDK3.2.1.37.2-1
The CrIS shall have a well defined vertical reference axis and perpendicular azimuth axis.

SRDK3.2.1.37.2-2
These axes shall be used for alignment of the CrIS LOS and the overall alignment of the CrIS to the NPOESS spacecraft.

3.2.1.37.3 Orientation of the Reference Axes

SRDK3.2.1.37.3-1
The CrIS shall have external optical alignment references to define the mechanical reference axes and establish the orientation of the mechanical reference axes relative to the spacecraft primary mechanical axes.

3.2.1.37.4 CrIS Line-of-Sight

SRDK3.2.1.37.4-1
The CrIS line-of-sight (LOS) shall be defined by the location of the center of the Instantaneous Field-of-Regard (TBR).

3.2.1.37.5 CrIS Line-of-Sight Pointing Knowledge

SRDK3.2.1.37.5-1
The line-of-sight pointing knowledge shall be less than or equal to 0.1 degree (TBR) for all absolute measurements and less than or equal to 0.05 degrees (TBR) for all relative measurements, in both in-track and cross-track directions. Variations in the elevation plane angle of each FOV, which may be characterized and shown to be repeatable or which are predictable from a knowledge of the scan mirror position, spacecraft attitude, and/or orbital position, are not to be included in this uncertainty budget. These systematic variations are to be predicted as part of the CrIS design, but reach final characterization after launch for removal by data processing techniques.

3.2.1.37.6 CrIS LOS Jitter

SRDK3.2.1.37.6-1
The line-of-sight shall be stabilized to 1% (TBR) of the FOV during the interferogram measurement.

3.2.2 SENSOR CAPABILITY RELATIONSHIPS

3.2.2.1 Reference Timelines

(TBD)

3.2.3 INTERFACE REQUIREMENTS

The system interfaces relevant to the sensors are depicted in Figure 3.2.3 below. Interface requirements for flight on other platforms (e.g., POES N and N’) are (TBS).

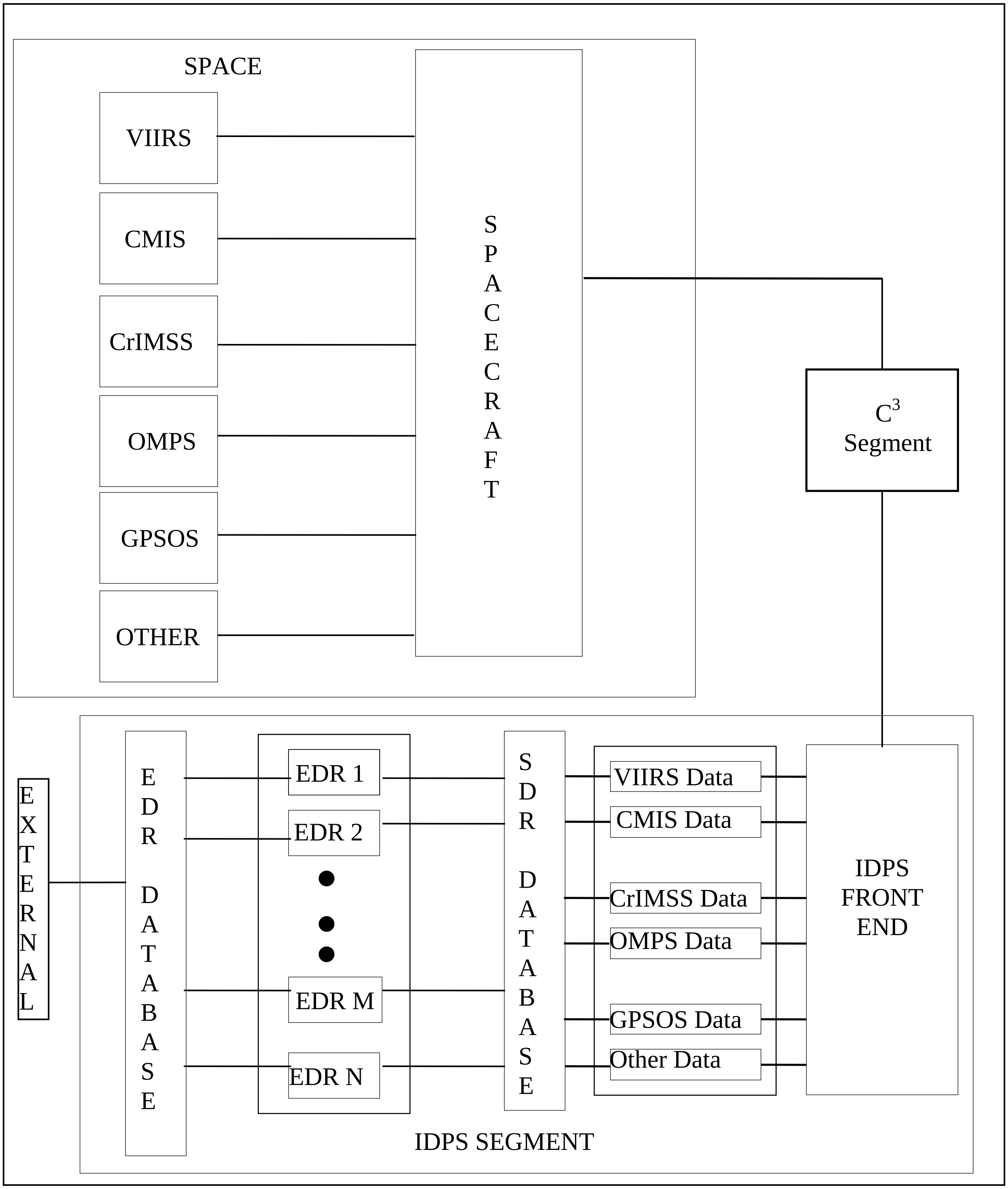

Figure 3.2.3 Partial System Internal Interfaces

3.2.3.1 External Interface Requirements

3.2.3.1.1 METOP Spacecraft Bus External Interface Description (TBS)

3.2.4 PHYSICAL AND INTERFACE CHARACTERISTICS

Weight, power, volume, and data rates described herein are nominal values (with contingency) which were developed during initial studies at the Integrated Program Office. All values are defined as: (TBR), indicating that specific allocations are negotiable. It is presently planned that definitive allocations will be defined by the IPO, in consultation with sensor contractors, by the time of the SRR. In the interim, contractors should keep in mind that relaxation from nominal allocations will only be possible if changes are consistent with the requirement to accommodate the full NPOESS payload suite of instruments on a spacecraft which can be placed into a nominal 833 Km orbit by an EELV class launch vehicle. The spacecraft-to-sensor interface requirements are broken down into four primary groups: mechanical, power, data, and thermal. A notional diagram of the top-level functional interfaces for any sensor is shown in Figure 3.2.4. In addition, environmental, software, testing, contamination, launch environment, and safety requirements are defined.

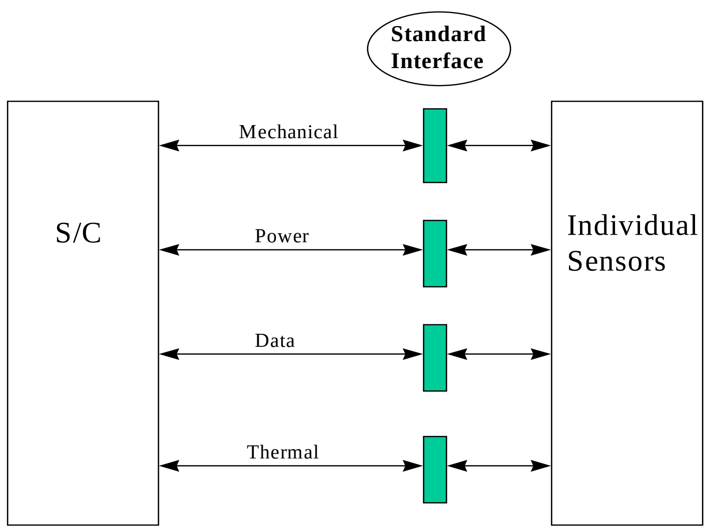

Figure 3.2.4. Notional Spacecraft-To-Sensor Functional Interfaces.

SRDK3.2.4-1
The mass of the CrIS sensor shall be less than or equal to 81 kilograms.

SRDK3.2.4-2
The stowed dimensions of the CrIS sensor shall be less than or equal to the following limits: Velocity direction: 61 centimeters.

a) Nadir direction: 40 centimeters.
b) Anti-Solar direction: 40 centimeters.

SRDK3.2.4-3
The power consumption of the CrIS sensor shall be less than or equal to 91 Watts.

SRDK3.2.4-4
The data rate of the CrIS sensor shall be less than or equal to the following limits:

a) Deleted.
b) High Resolution Data Rate: 1500 kilobits per second.
c) Deleted.

Continued in Common Section